

Effectiveness of Zinc Foliar Spraying on the Cracking of Pomegranate Fruits

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Abstract – Fruit cracking is one of the most important obstacles facing pomegranate cultivation, which inflicts great damage on the crop, sometimes reaching more than 70%. The research was carried out in the 2018 agricultural season in a field planted with pomegranate trees (French variety) in order to study the effect of foliar spraying with zinc in reducing fruit cracking. The experiment was conducted according to a complete randomized design (CRD). We had three treatments for zinc concentrations (0, 500, 1000 ppm) and four treatments for the number of spraying times (0, 1, 2, and 3 times). The results showed the superiority of all treatments of spraying with zinc over the control treatment in most of the studied traits. Also, increasing the number of spraying times with zinc reduced the percentage of fruit cracking, as the percentage of cracked fruits reached 73.96%, 21.48%, 15.91%, and 12.72% in the treatments of 0, 1, 2, and 3 spraying times respectively. Similarly, the increase in the spraying concentration achieved a significant reduction in the percentage of fruit cracking, which amounted to 17.10% and 14.43% in the treatments of concentrations A and B, respectively.

Keywords: Pomegranate, Fruit Cracking, Foliar Spraying, Zinc, Concentration, Number of Spraying Times.

I. INTRODUCTION

Pomegranate is one of the most widespread trees in the world, native to the regions of Central Asia, and from there it was transferred to the countries of the world (Chandler, 1957; Levin, 1994). It is currently grown in many geographical areas including the Mediterranean basin, Asia, the USA and India (Bankar and Prasad, 1992; Holland *et al.*, 2009).

Pomegranate is grown in Syria to a fair degree, and pomegranate cultivation is self-sufficient with the export of a small portion of the production. The cultivated area was estimated at 6600 ha planted with 3.7 million trees, producing about 107.5 million kg (SAAG, 2020). However, pomegranate cultivation in Syria is exposed to many problems that affect the quantity and quality of production, the most important of which is the problem of fruit cracking. The degree of sensitivity to this problem varies according to the variety. The

French variety is considered one of the most important varieties cultivated in northern Syria in terms of cultivated area and in terms of local demand for the fruits of this variety. However, due to the sensitivity of this variety to the problem of fruit cracking, the areas cultivated with it began to decrease and to move towards the cultivation of other crops (Draie and Aboras, 2021a).

The fruit cracking is one of the most important physiological diseases affecting fruits in general and pomegranates in particular (Malhotra *et al.*, 1983). Panwar *et al.* (1994) and Singh (1995) showed that when the fruits crack, they are susceptible to infection by pathogens, and thus lose their market value and become unfit for human consumption, causing a very large economic loss for pomegranate farmers (Finkel and Holbrook, 2000; Schrader *et al.*, 2002). Singh *et al.* (2006) and Bankar and Prasad (1992) confirmed that about 25-40% of the fruits crack at the time of ripeness, and these fruits lose their quality and become unfit for marketing and thus cause a great loss in production. The fruit cracking rate varies between 10-70% depending on climatic conditions, which reduces production to 50%, and this is harmful to the farmer (Anonymous, 1983; Draie and Aboras, 2021b).

The cracking of the pomegranate fruits is mainly attributed to genetic factors (cultivar), environmental factors, and various agricultural treatments (Saad *et al.*, 1988; Prasad *et al.*, 2003; Chandra *et al.*, 2011; Khadivi-Khub, 2014). Abd and Rahman (2010) indicated that the cracking phenomenon is associated with high temperature, high transpiration rate, low humidity in the air and soil, and sharp fluctuations in temperature between day and night during fruit growth. The correlation of the problem of cracking of pomegranate fruits with irregular irrigation and lack of nutrients has also been emphasized (Ghahsheikhsbayat, 2006; Khalil and Aly, 2013; Saeiet *et al.*, 2014; Galindo *et al.*, 2014). The degree of cracking also varies according to the stages of fruit growth, so cracking is more developed at the stage of fruit ripening (Hoda and Hoda, 2013; Shulman *et al.*, 1984; Yazici and Kaynak, 2006).

Khan *et al.* (1974) confirmed that the lack of some nutrients such as Zn leads to the occurrence of cracking, as the lack of nutrition, especially zinc, is directly related to the fruit

cracking in pomegranates (Ghariesheikhbayat, 2006; Saeiet *al.*, 2014). Michra and Khan (1981) also confirmed that spraying with zinc increased the size, weight, length and diameter of pomegranates. Bambalet *al.* (1991) showed that foliar fertilization of Ganesh pomegranate variety with some microelements such as zinc, led to an increase in production. Khan *et al.* (1974) also emphasized that the lack of some nutrients such as zinc causes cracking, and the need to spray with zinc sulfate to prevent the fruit cracking of the Rose Scented pomegranate variety.

This research was conducted with the purpose of studying the effect of spraying with zinc (different concentrations and different number of spraying times) on the possibility of reducing the cracking of pomegranate fruits in the French variety with the aim of preserving this locally desirable variety.

II. MATERIALS AND METHODS

2.1 Experimental Location

The research was carried out in the city of Sarmada, which is located on the Syrian-Turkish border. The city is about 40 km to the north of Idlib, and it is approximately 383 meters high. The total precipitation during the research season was 693 mm. The average of minimum temperatures for the coldest month was 2°C, and the average of maximum temperatures for the warmest month was 35°C.

2.2 Plant Materials

The experiment was carried out on French pomegranate trees, which have large, spherical to flattened fruits, with red skin and long necks. The seeds are surrounded by a bloody red pulp, the leaf is elongated, and the branches are spiny. The fruits of this variety are prone to cracking (Draie and Aboras, 2021a).

2.3 Experimental Design and treatments

The research was executed in the 2018 agricultural season in a field planted with French pomegranate trees at the age of 10 years and dimensions 4 x 4 m. The complete randomized design (CRD) was used.

The experiment included three treatments for the concentrations of zinc and four treatments for the number of foliar spraying times with zinc, according to the following:

- Zinc concentrations: 0, 500 (A), and 1000(B) ppm.
- Number of foliar spraying times: 0, 1, 2, and 3 times:
 - Control without spraying.

- Foliar spraying once after the beginning of flowering (1/5/2019).
- Foliar spraying twice after the beginning of flowering (1/5/2019) and after the completion of the fruit set (1/6/2019).
- Foliar spraying three times after the beginning of flowering (1/5/2019), after the completion of the fruit contract (1/6/2019), and when the fruits start to color (1/7/2019).

Five replicates per treatment, with one tree (French pomegranate variety) per replicate, were adopted. Consequently, the number of pomegranate trees used in the experimentation = 3 concentrations x 4 foliar spraying times x 5 replicates x 1 tree = 60 trees.

2.4 Measured Parameters

The following measurements were taken:

1) Flowering traits:

- Number of days until the starting of flowering.
- Number of total flowers.
- Number of hermaphrodite flowers.
- Ratio of hermaphroditic flowers (%).

2) Fruits-set and Yield characteristics:

- Ratio of fruit-set (%).
- Number of days until the date of fruits ripening.
- Productivity kg/tree.

3) Physical properties of fruits:

- Ratio of cracked fruits per tree (%).
- Diameter of fruit (cm).
- Weight of fruits (kg).
- Weight of fruit peel (g).
- Internal tissue weight (g).
- Weight of seeds (g).
- Weight of juice (g).

4) Fruit quality characteristics:

- Ratio of juice (%).
- Total Soluble Solids (T.S.S.%).
- Acidity of juice (pH).

2.5 Statistical analysis:

The results were analyzed by the statistical program (GenStat-12). The averages were compared by calculating the LSD at the level of significance (5%).

III. RESULTS AND DISCUSSION

3.1 Effect of spraying concentration with zinc on the studied characteristics

Table (1): Effect of spraying concentration with zinc on the studied characteristics

Trait \ Concentration (ppm)	0	500	1000	LSD _{5%}
Flowering	52.00	50.50	50.00	0.11
Ripening	151.00	147.50	145.00	0.12
Number of total flowers	287.33	428.04	470.77	1.89
Hermaphrodite flowers (%)	25.75	40.06	42.13	0.43
Fruit-set (%)	21.62	35.58	38.39	1.1
Diameter of fruit (cm)	8.32	11.44	11.87	0.14
Weight of fruits (g)	256.12	371.33	400.93	1.33
Weight of fruit peel (g)	60.99	83.30	85.81	0.58
Internal tissues weight (g)	59.12	74.13	75.85	0.84
Weight of seeds (g)	136.01	213.90	239.27	1.26
Ratio of juice (%)	27.32	40.03	42.91	0.19
Acidity of juice (pH)	2.98	3.32	3.40	0.03
Total Soluble Solids (T.S.S.%)	15.22	15.99	16.94	0.17
Productivity/tree (kg)	11.36	14.01	15.83	1.2

It is evident from Table (1) that all the foliar spraying concentrations with zinc exceeded the control in the number of days required to reach flowering (the value in the control was 52 days). The treatment of concentration B (1000 ppm) by 50 days exceeded the treatment of concentration A (500 ppm) by 50.50 days in the mentioned characteristic. The foliar spraying concentrations outperformed the control in reaching the ripeness of the fruits, as the control needed 151 days. The increase in the used concentration resulted in significant differences between the spraying treatments themselves, as the treatment of concentration B (1000 ppm) by 145 days outperformed the treatment of concentration A. (500 ppm) by 147.50 days.

The total number of flowers in the control was 287.33, the percentage of hermaphrodite flowers was 25.75%. The treatment of concentration A achieved a significant difference over the control with 428.04 flowers, which was also superior to the percentage of hermaphroditic flowers, which reached 40.06%. While the treatment of concentration B achieved a significant difference above the treatment of concentration A with the total flowers of 470.77 flowers, and the percentage of hermaphrodite flowers also, which amounted to 42.13%, (Table 1). Our study was in agreement with Shaheen (1995) who showed that increasing the spraying concentration led to an increase in the percentage of hermaphroditic flowers in pomegranate.

With regard to fruit-set, our study is consistent with Ozkaya (2004) where it was found that foliar spraying with microelements has a positive effect in increasing fruit-set through its positive role in increasing cell division and

activating the biosynthesis of organic compounds. Khorasandiet *al.* (2009) indicated that foliar fertilization with zinc increased the fruit-set for pomegranate trees. Bambal *et al.* (1991) and Khayatet *al.* (2007) also confirmed that foliar fertilization with zinc at the time of pomegranate flowering increased the fruit-set, as zinc plays an important role in regulating the absorption of water and many nutrients by the roots and increases the vitality of pollen and growth of the pollen tube. Where the percentages of fruit-set (in our research) were 21.62% in the control, 35.58% in the treatment of concentration A (500 ppm), and 38.39% in the treatment of concentration B (1000 ppm), as the differences were significant between all treatments, (Table 1).

The results of the statistical analysis according to Table(1) showed the significant effect of the concentrations used in the weight of the peel and the weight of the internal tissues of the fruit, as their weight in the control reached 60.99g and 59.12g, respectively. The treatments of concentration A and B achieved a significant difference on the control. Where the weight of the peel was 83.30g and the internal tissue weight was 74.13g in the treatment of concentration A (500 ppm). While the weight of the peel was 85.81g and the internal tissue weight was 75.85g in the treatment of concentration B. In addition, the treatment of concentration B being superior to the treatment of concentration A with clear significant differences.

The foliar spraying with zinc had a significant effect on the weight and diameter of the pomegranate fruit, as the weight of the fruit in the control reached 256.12g and the diameter was 8.32 cm. The treatment of concentration A achieved a

significant difference on the control, and the weight of the fruit was 371.33 g and the diameter of the fruit was 11.44 cm. Also, the treatment of concentration B achieved a significant difference on the treatment of concentration A, as the weight of the fruit was 400.93g and the diameter of the fruit was 11.87 cm. Similarly, the weight of the seeds increased due to the effect of foliar spraying with zinc, reaching 136.01g, 213.90g, and 239.27g in each of the control, the treatment of concentration A, and the treatment of concentration B, respectively (Table 1).

As for the percentage of juice, all concentrations of zinc spraying outperformed the control treatment, in which the juice percentage was 27.32%. The treatment of concentration B (1000 ppm) outperformed the treatment of concentration A (500 ppm) with percentage of juice of 42.91% and 40.03%, respectively, (Table 1). Our study coincides with Fayed (2010), who showed that increasing the spraying concentration of pomegranate trees from 700 ppm to 1000 ppm, this led to a significant increase in the percentage of juice in the fruit, and all treatments were superior to the control.

The acidity of the juice decreased (the pH value increased) due to the effect of foliar spraying with zinc. The pH value reached in control 2.98, in the treatment of concentration A (500 ppm) 3.32, and in the treatment of concentration B (1000

3.2 Effect of spraying times with zinc on the studied characteristics

Table (2): Effect of spraying times with zinc on the studied characteristics

Trait \ Spraying times (number)	0	1	2	3	LSD _{5%}
Flowering	52.00	51.00	50.75	50.00	0.13
Ripening	151.00	148.75	147.25	146.50	0.15
Number of total flowers	287.33	376.81	450.04	469.68	2.02
Hermaphrodite flowers (%)	25.75	39.58	42.60	42.84	0.50
Fruit-set (%)	21.62	34.88	36.37	37.73	1.04
Diameter of fruit (cm)	8.32	11.27	11.46	11.79	0.11
Weight of fruits (g)	256.12	345.50	368.74	393.82	1.58
Weight of fruit peel (g)	60.99	81.33	82.36	84.13	0.67
Internal tissues weight (g)	59.12	67.42	71.83	74.63	0.75
Weight of seeds (g)	136.01	196.75	214.55	235.06	1.37
Ratio of juice (%)	27.32	39.46	41.13	42.64	0.24
Acidity of juice (pH)	2.98	3.26	3.30	3.40	0.02
Total Soluble Solids (T.S.S.%)	15.22	15.76	16.41	17.04	0.19
Productivity/tree (kg)	11.36	13.60	14.28	15.65	1.07

Table (2) shows that all spraying treatments exceeded the control in the number of days required to reach flowering (as the value in the control was 52 days). The increase in the number of spraying times had a positive effect in this aspect, as the three-time spraying treatment (by 50 days) exceeded the twice spraying treatment (by 50.75 days), which outperformed the once spraying treatment (by 51 days).

ppm) 3.40, with significant differences among all treatments, (Table 1). Also, the percentage of T.S.S. increased by the effect of zinc foliar spraying, as its value in the control reached 15.22%. Significantly, all the treatments outperformed the control treatment, as the T.S.S. percentage in the treatment of concentration B reached 16.94%, and it outperformed the treatment of concentration A, in which the T.S.S. percentage was 15.99% (Table 1). These results are consistent with Khorasandi *et al.* (2009) who confirmed that foliar fertilization with zinc improves the specific properties of pomegranate.

Table (1) also indicates the significant effect of spraying with zinc on the productivity of the French pomegranate variety, where the productivity of the control reached 11.36 kg/tree. The treatment of concentration A (500 ppm) achieved a significant increase over the control and the productivity reached 14.01 kg/tree. The treatment of concentration B (1000 ppm) achieved a significant increase over the treatment of concentration A, with a productivity of 15.83 kg/tree. The differences were significant between all treatments. The spraying treatments achieved an increase in productivity over the control by 123.33% and 139.35% in the treatments of concentration A and B, respectively. Our study is consistent with (Khayyat *et al.*, 2007), which showed that foliar fertilization with zinc at the time of pomegranate flowering led to an increase in production.

Table (2) also shows the significant effect of spraying in reaching the stage of fruit ripeness, as all treatments exceeded the control treatment, which required 151 days, and the increase in the number of spraying times led to significant differences between the treatments. The three-time spraying treatment (by 146.50 days) outperformed the twice spraying

treatment (by 147.25 days), which outperformed the once spraying treatment (by 148.75 days).

Also, increasing the number of times spraying with zinc had a significant effect on increasing the number of total flowers and the percentage of hermaphroditic flowers. The total number of flowers in the control reached 287.33, of which 25.75% were hermaphrodites. The treatment of once spraying achieved a significant superiority over the treatment of the control, and the total number of flowers in it was 376.81 and by the percentage of hermaphrodite flowers 39.58%. The treatment of twice spraying achieved a significant superiority over the treatment of once spraying and the number of total flowers in it reached 450.04 flowers, of which 42.60% were hermaphroditic flowers. While the treatment of the three-time spraying outperformed all the treatments, the total number of flowers was 469.68, of which 42.84% was a hermaphrodite (Table 2).

Spraying and increasing the number of spraying times had a clear significant effect on the percentage of fruit-set, as the ratios reached 21.62%, 34.88%, 36.37%, 37.73%, in the control, the treatment of once spraying, the treatment of twice spraying, and the treatment of the three-time spraying, respectively, as the differences were significant between all treatments, (Table 2).

The results of the statistical analysis according to Table (2) showed the significant effect of increasing the number of spraying times on the weight of the peel and the weight of the internal tissues of the fruit, as their weight in the control reached 60.99g and 59.12g, respectively. All the foliar spraying treatments achieved a significant superiority over the control treatment, as the weight of the peel was 84.13 g and the internal tissue weight was 74.63 g in the three-time spraying treatment, while in the treatment of twice spraying, the weight of the peel was 82.36 g and the weight of the internal tissues was 71.83 g, and in the treatment of once spraying, the weight of the peel was 81.33g and internal tissue weight was 67.42g. The differences were significant between all treatments.

Table (2) shows the significant positive effect of spraying and the increase in the number of spraying times on increasing the weight of the seeds, compared to the control in which the weight of the seeds reached 136.01g. The treatment of once spraying surpassed the control, and the weight of the peel in it was 196.75g, and the treatment of twice spraying achieved a significant increase over the treatment of once spraying, and the weight of the seeds in it was 214.55g. The treatment of three-time spraying achieved a significant increase over the treatment of the twice spraying, and outperformed all treatments, with a weight of 235.06g.

Spraying and increasing the number of spraying times had a significant effect on increasing the weight and diameter of the fruit, as the weight of the fruit in the control reached 256.12g and its diameter reached 8.32 cm. Once spraying treatment achieved a significant difference on the control, as the weight of the fruit in it was 345.50g and the diameter of the fruit was 11.27 cm. The treatment of twice spraying achieved a significant difference compared to the treatment of once spraying, as the weight of the fruit in it was 368.74g and the diameter of the fruit was 11.46 cm. The treatment of three-time spraying achieved a significant difference over the treatment of twice spraying, as the weight of the fruit was 393.82g and the diameter of the fruit was 11.79 cm (Table 2). Michra and Khan (1981) also confirmed that spraying with zinc increased the size, weight, length and diameter of pomegranate fruits.

Table (2) also shows the significant effect of spraying and increasing the number of spraying times in the proportion of juice, as this percentage in the treatments reached 27.32%, 39.46%, 41.13%, and 42.64% in the control, the once spraying, the twice spraying, and the three-time spraying, respectively. In addition, the three-time spraying treatment outperformed the other treatments, as the differences were significant between all treatments.

Foliar spraying with zinc decreased the acidity of the juice (an increase in the pH value), where the pH value of the control reached 2.98. The increase in the number of spraying times achieved clear significant differences in this characteristic between the spraying treatments themselves. The treatment of once spraying significantly exceeded the control, as the pH value in it was 3.26. Also, the treatment of the twice spraying outperformed the once spraying treatment, as the pH value in it was 3.30. The treatment of the three-time spraying outperformed all treatments, as the pH value in it was 3.40, (Table 2).

Also, the percentage of T.S.S. increased due to the effect of zinc foliar spraying, as its value in the control reached 15.22%. All treatments were significantly superior to the treatment of the control, as the total T.S.S. percentage in the three-time spraying treatment reached 17.04%, which was significantly superior to the twice spraying treatment, in which the T.S.S. reached 16.41%. Similarly, the treatment of twice spraying surpassed the once spraying treatment, in which the T.S.S. reached 15.76%, (Table 2).

Table (2) indicates the significant effect of increasing the number of times spraying with zinc on the productivity of the French pomegranate variety, as the productivity of the control reached 11.36 kg/tree. The treatment of once spraying achieved a significant increase on the control with a

productivity of 13.60 kg/tree. Also, the treatment of the twice spraying achieved a significant superiority over the once spraying treatment, with a productivity of 14.28 kg/tree. While the treatment of the three-time spraying significantly outperformed all treatments, with a productivity of 15.65 kg/tree. The spraying treatments achieved an increase in productivity over the control by 119.72%, 125.70%, and 137.76% in the once, twice and three-time spraying treatments, respectively. Our study is consistent with Bambal *et al.* (1991) and El-khawaga (2007) where they confirmed that foliar fertilization of pomegranate trees with iron 0.4%, boron 0.2%, manganese 0.3%, and zinc 0.3%, alone or in combination, led to a significant increase in the productivity.

Table (3): Effect of interaction of the spraying concentrations and spraying times with zinc

Spraying times	Spraying concentration	fruit-set (%)	Peel weight (g)	Fruit weight (g)	Fruit diameter (cm)	Juice ratio (%)	T.S.S. (%)	Juice pH	Yield (kg/tree)
Control		21.62	60.99	256.12	8.32	27.32	15.22	2.98	11.36
1	500 ppm	34.06	80.57	328.26	11.29	38.27	15.29	3.26	13.29
	1000 ppm	36.87	86.04	396.20	11.52	41.05	16.29	3.33	14.56
2	500 ppm	35.86	83.13	337.07	11.39	40.18	15.98	3.28	14.02
	1000 ppm	38.39	87.49	422.28	11.82	43.00	16.95	3.39	15.41
3	500 ppm	36.83	86.20	343.47	11.63	41.52	16.69	3.41	14.72
	1000 ppm	39.91	89.91	440.71	12.28	44.69	17.57	3.47	17.50
LSD _{5%}		2.08	1.33	3.86	0.22	0.48	0.38	0.04	1.10

The binary interaction of concentrations B and three-time spraying outperformed the other interactions, in the fruit-set ratio with a value of 39.91%, in the weight of the fruit peel with a value of 89.91 g, in the weight of the fruit with a value of 440.71 g, in the diameter of the fruit with a value of 12.28 cm, in the proportion of juice 44.69%, in the percentage of T.S.S. with a value of 17.57%, in the acidity of juice with a value of 3.47, and in the total productivity of the tree with a value of 17.50 kg/tree. Then came the binary interactions of concentration B with twice spraying, concentration B with once spraying, concentration A with three-time spraying, concentration A with the twice spraying, then finally, concentration A with once spraying, respectively, in most of the studied characteristics. These results show the largest effect of the spraying concentration factor with zinc compared to the number of times spraying with zinc, as increasing the spraying concentration achieved greater effectiveness and led to the improvement of the studied characteristics compared to the increase in the number of spraying times.

3.4 Effect of spraying with zinc on the fruit cracking

Foliar spraying with zinc significantly reduced the percentage of cracking of fruits compared to the control (Fig. 1), as the percentage of cracked fruits in the control reached 73.96%. The treatment of concentration A (500 ppm) achieved

3.3 Effect of interaction between the spraying concentrations and spraying times with zinc on the studied characteristics

The interaction between the concentrations of spraying with zinc (concentration 500 ppm, and the concentration 1000 ppm) and the number of spraying times with zinc (spraying once, spraying twice, and spraying three times) had a significant effect on the whole studied characteristics compared with the control (Table 3).

a significant decrease compared to the control, with a percentage of cracked fruits of 17.10%. Whereas, the treatment of concentration B (1000 ppm) attained a significant decrease compared to the treatment of concentration A by 14.43%, (Fig. 1).

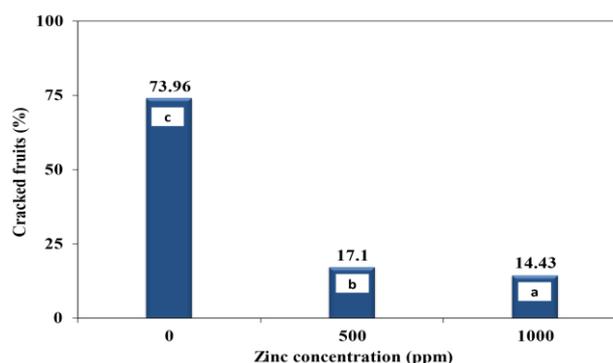


Figure 1: Effect of spraying concentration with zinc on the fruit cracking (LSD_{5%}=0,24)

Also, spraying and increasing the number of spraying times had a significant effect in reducing the percentage of cracked fruits compared to the control. The once spraying achieved a significant decrease compared to the control, with a percentage of cracked fruits of 21.48%. Similarly, the treatment of twice spraying reached a significant decrease in the cracking rate, which amounted to 15.91% compared to the

treatment of once spraying, as the percentage of cracked fruits was 12.72%. Moreover, the treatment of twice spraying significantly outperformed the other treatments, (Fig. 2).

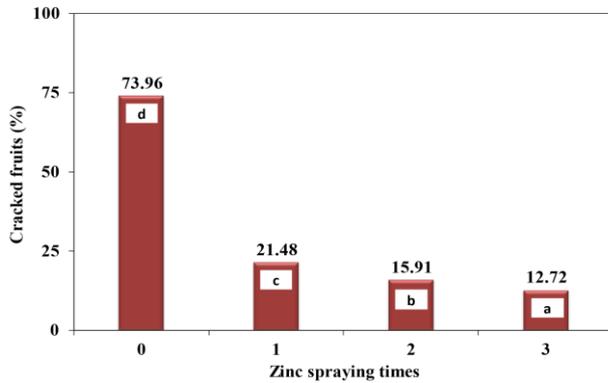


Figure 2: Effect of spraying times with zinc on the fruit cracking (LSD_{5%}=0.35)

As for the interaction between the concentrations of spraying with zinc (0, 500, and 1000 ppm) and the number of times spraying with zinc (0, 1, 2, and 3 times spraying), the effect was significant in reducing the percentage of cracking of the fruits of the French pomegranate variety compared to the control, in which the rate of cracking was 73.96%, (Fig. 3). The binary interaction of concentration B and the three-time spraying outperformed the other interactions by 20.25%, followed by the interaction of concentration B with the twice spraying by 26.69%, followed by A with the three-time spraying by 26.61%, then the interaction of concentration A with the twice spraying by 32.86%, then concentration B with the once spraying by 39.61%, then finally the interaction of concentration A with once spraying by 43.15%, where the differences were significant between all these interactions.

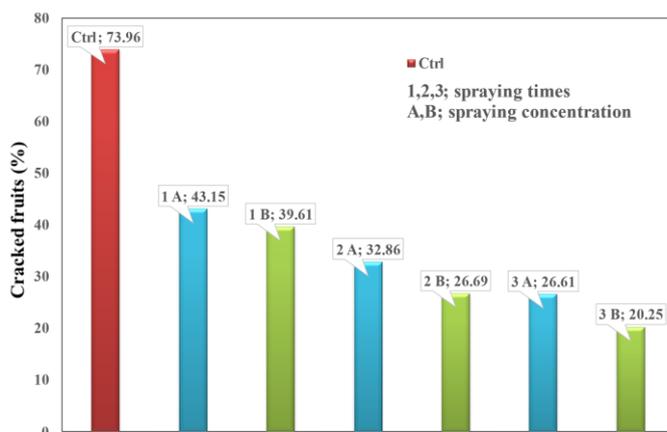


Figure 3: Effect of interaction between the spraying concentration and spraying times with zinc on the fruit cracking (LSD_{5%}=0,64)

Our results coincide with many studies that showed the importance of spraying with zinc in reducing the rate of cracking of the pomegranate and its negative effects. Reducing

the percentage of cracking in fruits in response to the use of zinc is mainly attributed to its important role in regulating the absorption of water by the roots and many nutrients that control fruit cracking. Zinc affects nitrogen activity and carbohydrate kinetics. Zinc plays major roles in chlorophyll, protein, and DNA, and zinc affects photosynthesis by altering chloroplast, electron transport systems, photosynthesis, CO₂ fixation, and increasing the chlorophyll content (Ramezani and Shekafandeh, 2011). El-Khawaga (2007) indicated that the foliar spraying with the hormone Paclobutrazol and zinc sulfate reduced the percentage of cracked pomegranate fruits. Khan *et al.* (1974) also emphasized that the lack of some nutrients such as zinc causes cracking, and the need to spray with zinc sulfate to prevent the fruit cracking of the Rose Scented pomegranate variety.

IV. CONCLUSIONS

- 1) All treatments of spraying with zinc outperformed the control treatment in most of the studied traits (early flowering and ripening time, increasing the percentage of fruit-set, improving the quality of fruits).
- 2) The increase in the number of spraying times with zinc had a significant positive effect in increasing the productivity compared to the control. The increase was 119.72%, 125.70%, and 137.76% in the treatment of once, twice, and three-time spraying, respectively.
- 3) The increase in the used concentrations had a significant positive effect in increasing the productivity compared to the control. Wherever, the increase was 123.33% and 139.35% in the treatments for the concentrations A and B, respectively.
- 4) The increase in the number of times spraying with zinc reduced the percentage of fruit cracking compared to the control, as the percentage of cracking of fruits reached 21.48%, 15.91%, 12.72%, in the treatment of once, twice, and three-time spraying, respectively.
- 5) The increase in the concentration spraying with zinc led to a reduction in the percentage of fruit cracking compared to the control, as the percentage of cracking fruits was 17.10% and 14.43% in the concentration treatments A and B, respectively.

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